FUEL SYSTEM

FIELD OF THE INVENTION

[0001] This invention relates to a fuel system for use in delivering fuel to a cylinder of an associated compression ignition internal combustion engine of the type provided with an after treatment device for the purpose of emission level control. The invention also relates to a method of delivering fuel to an engine.

BACKGROUND OF THE INVENTION

[0002] Known fuel systems commonly include a fuel pump having one or more cam driven plungers arranged to pressurise fuel within a pumping chamber for delivery to the injectors of the associated engine. In a unit pump/injector scheme, a single plunger is driven to pressurise fuel within a pumping chamber, from where high pressure fuel is delivered to the delivery chamber of an injector located within a housing common to the pump elements. Alternatively, the pump and the injector may communicate through a separate high pressure fuel line interconnecting the pumping chamber with an injector delivery chamber.

[0003] It is a recent development in diesel engine technology to provide the engine with an after treatment device for the purpose of improving exhaust emission levels. For regeneration purposes, such devices periodically require an injection of fuel to the engine sometime after a main injection event (referred to as "late post injection"). Typically, such late post injection of fuel may be required several times for any one tank of fuel used.

[0004] It is an object of the present invention to provide a fuel system which enables this to be achieved.

SUMMARY OF THE INVENTION AND ADVANTAGES

[0005] According to a first aspect of the invention there is provided a fuel system for use in an internal combustion engine, the fuel system comprising;

[0006] a fuel pump having a pumping cycle during which fuel is pressurised to a high level within a pumping chamber for delivery to an injector, whereby the injector is arranged to provide a primary fuel injection event, and a secondary fuel injection event within the same pumping cycle, in use,

[0007] the injector including a valve needle which is engageable with a valve needle seating to control fuel delivery through an injector and injection control valve means, in the form of an injection control valve arrangement, for controlling movement of the valve needle so as to control the primary and secondary fuel injection events,

[0008] the fuel system further comprising an accumulator volume for storing high pressure fuel for delivering the secondary fuel injection quantity, and additional valve means, in the form of an additional valve arrangement, for controlling the supply of fuel stored within the accumulator volume to the injector for the secondary injection event.

[0009] For the purpose of this specification, the phrase "secondary injection event" is not limited to an event which occurs later than a "primary injection event" in a pumping cycle, and the secondary injection event may equally occur before the primary injection event.

[0010] The fuel system is particularly suitable for use in an engine provided with an after treatment device for reducing emission levels. In such circumstances, the primary injection event takes the form of a main fuel injection event, during which a main fuel injection quantity is delivered, and the secondary injection event takes the form of a late post injection event, during which a late post fuel injection quantity is delivered, whereby the late post injection of fuel occurs after the main injection of fuel in the pumping cycle.

[0011] The after treatment device associated with the engine may be a nitrogen oxide absorber type device (a NOx absorber device), in which case the additional valve arrangement is preferably arranged to deliver a late post fuel injection quantity which may be approximately the same as the main fuel injection quantity.

[0012] Alternatively, if the after treatment device is of the diesel particulate filter (DPF) type, the additional valve arrangement is preferably arranged to deliver a late post fuel injection quantity which may be approximately between 5% and 20% of the main fuel injection quantity.

[0013] In one embodiment, the injection control valve arrangement and the additional valve arrangement may be arranged to provide a sequence of typically around 3 to 5 consecutive main fuel injection events, each of which is accompanied by a late post fuel injection event. Preferably, this sequence may be provided once for each tank of fuel used.

[0014] In another embodiment, the injection control valve arrangement and the additional valve arrangement may be arranged to provide a periodic distribution of late post fuel injection events between main fuel injection events. The late post fuel injection events may typically be provided between 3 and 5 times for each tank of fuel used by the engine. The number of late post fuel injection events will be selected according to the requirements of the engine/after treatment device specifications.

[0015] The additional valve arrangement may conveniently take the form of an electronically operable valve, preferably an electromagnetically operable valve. In one embodiment, the additional valve arrangement includes an electromagnetically operable actuator for switching the additional valve arrangement between open and closed states, wherein the actuator is common to the injection control valve arrangement.

[0016] In one particularly preferred embodiment, therefore, the fuel system comprises a fuel pump having a pumping cycle during which fuel is pressurised to a high level within a pumping chamber for delivery to an injector, whereby the injector is arranged to provide a main fuel injection event and a post fuel injection event, during within the same pumping cycle, the injector including a valve needle which is engageable with a valve needle seating to control said fuel delivery and an injection control valve arrangement for controlling movement of the valve needle so as to control the main and post fuel injection events, the fuel system further comprising an accumulator volume for storing high pressure fuel for delivering the post fuel injection quantity, and an additional valve arrangement which is